

BIOLOGICAL OBSERVATIONS ON  
PSAMMAECIUS ADORNATUS (BRADLEY)

(Hymenoptera: Sphecidae)

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The solitary wasps of the gorytine genus *Psammaecius* are ground nesting species which utilize membracids and cicadellids as prey. Most of the known biological information on the North American species is based on two eastern species, *P. costalis* (Cresson) (Reinhard 1925a, b) and *P. tricolor* (Cresson) (Evans, Yin, and Yoshimoto 1954). Evans *et al.* have reviewed the literature on the biological knowledge of the genus in their discussion of *P. tricolor*.

An active nesting site of *Psammaecius adornatus* (Bradley) was located May 17, 1958 on Mt. Diablo, Contra Costa County, California. Intermittant observations were made during the afternoon of that day, and the same site was revisited on May 21 during the morning hours. The species was found nesting at Arroyo Seco, Monterey County, California at approximately the same time by E. G. Linsley, J. W. MacSwain and R. M. Bohart, and they contributed additional observations.

We are indebted to several specialists for the determination of the species cited below: Dr. R. M. Bohart, University of California, Davis (the *Psammaecius*, Nyssonini and Chrysididae), Dr. F. R. Cole, University of California, Berkeley (Bombyliidae), W. E. Ferguson, University of California, Berkeley (Mutillidae), Professor H. J. Reinhard, Texas A. and M. (Sarcophagidae) and Miss Louise Russell, U.S. National Museum (Membracidae). Acknowledgment is also made to Marius S. Wasbauer, University of California, Berkeley, for reading the manuscript and offering helpful suggestions.

The Mt. Diablo site was located along the sandy border of a level, gravel-covered parking area at an approximate elevation of 1500 feet on the southwest slope of the mountain. The unshaded area occupied by the site extended in a five foot wide strip for about 65 feet along the edge of the roadway. There were estimated to be 60 to 80 active female wasps within this area during the period of observation, however nearly all of the observations were made in a zone of about five by ten feet where over half of the wasps were concentrated. Ground cover here was sparse,

consisting of scattered clumps of *Erodium cicutarius* l'Her. and a small amount of grass, oak leaves and other debris. The weather during the two days of observation was essentially clear and warm, although on the latter (May 21) some high cloudiness reduced activity slightly at times.

Accumulated observations over the two days indicated a general behavior pattern for the females as follows. The night is apparently spent removed from the site. Morning observations began at 8:10 A.M. (Pacific Daylight Time) while the sun was still partially obscured by morning fog and activity at the site had not yet commenced. Females were soon observed, apparently flying in from other areas. The first was observed at 8:45, and by 9:15 individuals were fairly numerous about the observation area. At first the females alighted on open areas in the sunlight, remaining still or only moving the body up and down. Individuals went through these motions for 10 to 20 seconds before flying a short distance away. It is assumed that this was a warming up process. Following this, the females crawled about and scratched in the loose surface sand for some minutes before finally selecting a suitable burrow site. The search for burrow sites had begun by 9:15 (when it was already quite warm) and many successful burrows were under way by 9:30. Digging operations continued for about two hours before provisioning began, which by noon was well under way. The prey consisted entirely of membracid nymphs, primarily a species of some genus of Ceresini, possibly *Stictocephala*, although two females were taken on May 17 with nymphs of a larger prey species, possibly some genus of Telamonini. The transport of prey to the burrows lasted through the afternoon until temperatures began to drop. A few wasps were still evident around the site after 5:30 P.M., but none with prey. It seems unlikely that the females spend the night in their burrows since we were unable to recover any during evening excavations in the nesting area. We were unable to determine the location of the resting sites of the females.

Males were collected about the site during the early afternoon hours at the height of provisioning activities but not in the morning while the females were digging. One male was swept from a nearby oak, the host of the membracids, late in the afternoon.

Apparently a new burrow is constructed by the female each morning. The precise location of burrows varied; most were in open areas, often in slight depressions, some were adjacent to pebbles or other debris, while others were under oak leaves or under clumps of *Erodium*. The digging process seemed to be rather consistent, with only slight individual variations. The digging was commenced with the forelegs, the wasp always being directed head first. As the burrow deepened, sand was kicked back almost continuously with the hind legs. After five to ten minutes the wasp had lengthened the burrow so as to disappear completely into it. As the burrow progressed, the length of time spent in the burrow increased with the wasp periodically reappearing. Upon each reappearance the wasp would back-up four or five centimeters from the entrance, pause a few seconds, then gradually progress forward to the entrance kicking the loose sand behind. This procedure resulted in a shallow trackway of loose sand curving away from the burrow. During the initial stages of the digging the wasp could be seen reappearing often, however after half an hour or more of the operation, from three to over five minutes were usually spent below the surface. In the final stages the wasp reappeared head first forcing the sand out ahead of her. After this type of emergence the female would repeat the previously described procedure of removing the loose sand. Construction of the burrow took two to two and one-half hours in the few cases in which the entire process was observed. This appeared to be the approximate time required for most of the burrows since most of the individuals in the colony began provisioning at about the same time. The earliest time of completion of any burrow under surveillance was 11:20 A.M.

The first indication of termination of the digging operation was the behavior of the female in covering the entrance. Sand was kicked backward over the aperture from all sides, periods of kicking being alternated with short hovering flights one to two cm. above the burrow. After two or three minutes the burrow was reentered for a few seconds. Upon emergence the entrance was again covered and the wasp resumed the short hovering flight, this time six to eight cm. high. In one instance this reentry and covering process was twice repeated. Following the short flights, the female made several longer hovering arcs

a meter or more above the burrow site before flying away. It is assumed that this behavior pattern, involving repeated coverings of the burrow and hovering flights, is one of area recognition by the female wasp.

Although the first female was seen to return with prey at 10:57 A.M., provisioning of most burrows did not begin until nearly an hour later. By noon the burdened females were appearing almost continuously.

Each of the wasps carried the prey in a similar manner, grasping it with the hind legs. The treehopper nymph was held under the wasp's abdomen in a venter-up position with its head oriented forward. The wasps were usually first seen flying into the nesting area with prey two or three meters above the ground. Upon attaining a position approximately above the burrow at this height, the female initiated a very characteristic descent. Assuming a hovering action, the wasp rapidly dropped to within a meter of the sand while orienting herself into a position directly over the burrow. The final part of the descent was made with gradually diminishing speed, requiring eight or ten seconds, until the wasp briefly hovered just above the burrow before alighting. After a few seconds pause the female quickly opened the burrow entrance with her fore legs and entered, without changing the position of the prey. Usually about 20 seconds (8 to 30 seconds) were spent in the deposition of the prey. Usually the burrow entrance was covered upon each departure. Closure after the first time or two was affected by merely kicking sand backward over the entrance from one direction before flying directly off. There was considerable variation expressed by every individual observed in the time required for provisioning flights and there was no apparent correlation in differences between the length of time required by individuals. One made 14 observed trips ranging from two to 20 minutes with an average of nine minutes, another made nine trips ranging from two to 17 minutes and averaged ten minutes. A third ranged from three to 14 minutes in 11 trips averaging about seven minutes. It is not definitely known at what distance the source of prey was located, but *Stictocephala* nymphs were swept in small numbers from nearby (20-30 feet distant) *Quercus agrifolia*.

Observations were interrupted in the early afternoon on May 17 for 40 minutes and concluded in the evening at 4:15 P.M.

before the provisioning activities had ceased entirely, so that the number of trips per day is not definitely known. Judging from the frequency of trips during the observation periods in the two days, it is estimated that about 20 to 25 nymphs were carried in each day. Since it was later determined that each cell was provided with 12 or 13 membracids, we assume that the normal pattern of activity involves the provisioning of two cells each day. However, in our excavation we were unable to definitely correlate two cells with any particular burrow.

When our excavations were commenced at 5:30 P.M. there were still one or two wasps active about the site, but provisioning had apparently ceased. The filling of the tunnels had already been completed and was not observed. We found that it was impossible to trace the tunnels of marked burrows in these evening excavations. Evans *et al.* (1954) state that *P. tricolor* (Cr.) probably fills the burrow by scraping sand from the sides, and a similar behavior with *P. adornatus* seems probable and would account for the obliteration of the tunnel. Subsequent excavation of open burrows in the early afternoon of May 21 revealed the nature of the tunnels.

The soil in the area was found to consist of an upper layer of unconsolidated fine sand about seven or eight cm. in depth with an underlying layer of hard packed clay loam. Seven of the burrows were successfully exposed by tracing their courses with dry straws. These were found to show considerable variation in formation but not in depth. In general the tunnels were found to be about seven cm. in length (range 6.5 to 17 cm.) angling into the ground at about 30° to 40° with one bend, usually about halfway along the length but sometimes immediately after the entrance. The bend varied from 60° to 90° laterally from the original course either to the right or left with a steepening sometimes occurring after the bend. The tunnel terminated in an oval cell measuring about 6 mm. by 15 mm. with its long axis oriented with the tunnel direction. Nearly all of the cells were found just at the base of the loose sand, about 5 to 6 cm. below the surface.

In addition to the cells associated with the tunnels, numerous other cells were uncovered, presumably the result of earlier activity by the colony. Fully provisioned cells were found to contain 12 to 14 ceresine nymphs. However one cell contained

11 telamonine nymphs and two of the smaller Ceresini. Several of the wasp eggs were also covered. The whitish egg is elongate, smooth and slightly curved, tapering at both ends and measuring about 2.5 mm. in length and 0.5 mm. in width. The position of the egg was constant, lying longitudinally along the venter of the thorax of the treehopper just laterad of the coxae. One small larva and one fairly mature larva were found. These were presumed to be those of *P. adornatus* although numerous adults of three nyssonine parasites were active in the area.<sup>1</sup> In feeding, the larva removes the contents of the prey body, leaving the exoskeleton intact except for the abdominal sternites or the entire sternum.

A number of insects of parasitic groups were collected in the nesting site during the two days of observations, certain of which seem to have a definite relationship with *P. adornatus*.

Two species of *Epinysson* and one *Nysson* were seen in numbers about the nesting area. Since members of the group are said to be cleptoparasites of gorytine wasps (Evans *et al.*, 1954), these seem to be definitely associated with the species under study. The most abundant of these was *Epinysson moestus* (Cresson) both sexes of which were active during most of the day. Females of this species were taken at the nesting site before 9:00 A.M. while still very sluggish and behaving similarly to the early *Psammaecius* females. Activity of both sexes was quite pronounced before construction of the burrows by *P. adornatus* had been completed and continued throughout the afternoon. Individuals were frequently seen investigating or entering open burrows or other holes. One was seen to enter a burrow with the digging occupant inside. The parasite emerged about three seconds later, flew out a few inches, reentered the burrow, and then both came out after a few seconds. Another was observed to dig its way into a temporarily closed burrow and remain within for almost eight seconds. The wasp, a female, was collected upon its reappearance. Six females and three males of *Epinysson pumilis* (Cresson) were taken during the afternoon, and 12 females of *Nysson rusticus* Cresson were also collected while the provisioning of *Psammaecius* was in progress. A single male of the latter nyssonine was taken late in the afternoon.

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<sup>1</sup> The larvae have been sent to H. E. Evans for further study.

Several additional species known to be parasites of Hymenoptera were observed but had no apparent definite association with *P. adornatus* other than their occurrence in the nesting area. The hymenopterous parasites included the following: Chrysididae; *Omalus cressoni* Aaron, one female and *Hedychridium* sp. three females, (both species collected in the afternoon). Mutillidae; *Dasymutilla californica* (Radoszkowski), two females (11:10 A.M., 4:30 P.M.) and *Sphaerophthalma* sp., one female (8:30 A.M.). Among the Diptera were: Bombyliidae; *Lepidanthrax inaurata* Coquillett, one male and female (afternoon), Sarcophagidae; *Senotainia* sp. nr. *vigilans* Allen, one female (afternoon), *Senotainia trilineata* van der Wulp, one female (late afternoon), *Metopia leucocephala* (Rossi) two females (late A.M.).

Additional observations by Linsley, MacSwain, and Bohart on *Psammaecius adornatus* (Brad.) at Arroyo Seco, Monterey County, California showed that the nesting activities were going on concurrently with the Mt. Diablo population. The provisioning behavior at the Arroyo Seco colony was reported to be almost identical with that described above. The prey here also consisted of an undetermined membracid nymph.

#### LITERATURE CITED

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### A NEW SPECIES OF CHAETOSTOMA FROM CALIFORNIA

(Diptera: Tephritidae)

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The tephritid herein described has been confused for many years with *Chaetostoma rubida* (Coquillett) because of its close relationship to that species. D. W. Coquillett described *rubida* in 1899 and placed it in the genus *Epochra*. The type (U.S. National Museum No. 4397) is from Colorado.

Recent study of California *Chaetostoma* specimens in the